OCTOBER 22, 1984

CHEMICAL & ENGINEERING

NEWS

1985 Employment Outlook

For undergraduates, the core chemistr courses are not enough Page 29

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News of the Week

■ **Nobel Prize in Chemistry goes to R. Bruce Merrifield, U.S. protein biochemist; physics prize shared by Carlo Rubbia, Simon Van der Meer.** **Page 6**

■ **Panel of atmospheric chemists calls for U.S. to take the lead in understanding chemistry of the troposphere.** **Page 7**

■ **American Cyanamid sells titanium dioxide business to NL Industries and its Formica Brand Products business to newly formed company.** **Page 8**

■ **National Science Board gets three new members, all with technology and business backgrounds.** **Page 8**

Business

Chemical industry's high rate of earnings growth is beginning to show signs of slowing. **Page 11**

Government

House committee's planned two-year study of science policy will be huge, may explore politicization of science. **Page 16**

Science

Nonvolatile, proteinaceous pheromone discovered that elicits copulatory behavior in golden hamsters. **Page 21**

New service identifies most-cited lab instrument makers and where lab instruments are used. **Page 23**

Awards

Atmospheric chemistry, high-tech materials, designed synthesis of aromatic compounds, separations technology, macromonomer chemistry, and mass spectrometry on Mars—all are in the limelight from the work of the 1985 ACS awardees. **Page 58**

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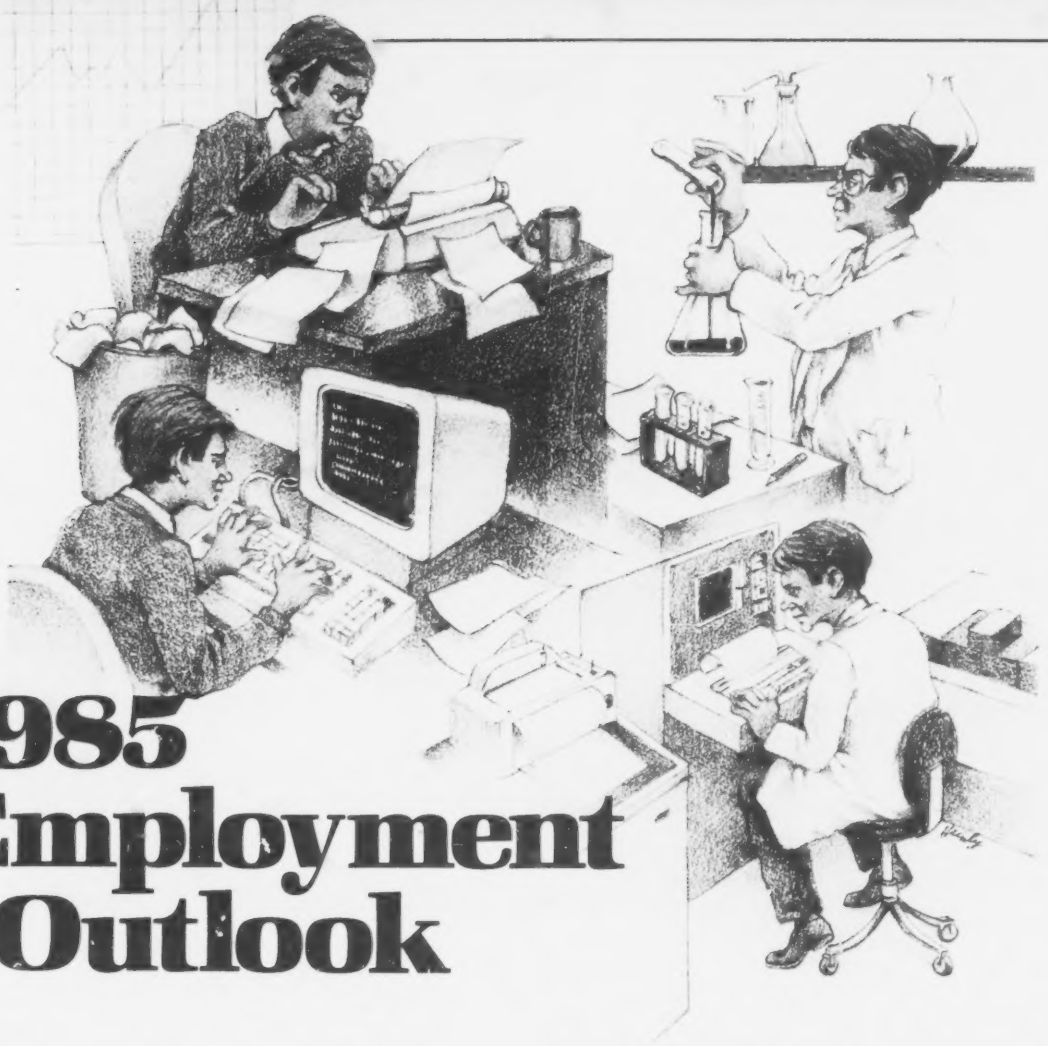
Employment Outlook

Improved demand for chemists and chemical engineers brightens the outlook for students interested in pursuing careers in these fields. **Page 29**



1985 Employment Outlook

Career Opportunities for Chemical Professionals

The upturn in the nation's economy has resulted in a noticeable improvement in demand for chemists and chemical engineers. At many colleges and universities, employers were considerably more active in recruiting graduating chemical professionals last spring than they had been a year earlier. Employers also had more jobs to offer than they did in 1983. The result is that fewer graduates this year found themselves without jobs to look forward to when they received their diplomas.

After two consecutive years of decline, the median annual starting salary of B.S. chemists increased this year. As it has for some years, the median annual starting salary of Ph.D. chemists likewise increased in 1984. Rises also were noted in the median starting salaries of B.S., M.S., and Ph.D. chemical engineers.

The volume of "positions open" advertising in C&EN this year is strikingly higher than the year before. At the ACS national meeting in Philadelphia this past August, too, the mood of employers and job applicants was described as decidedly upbeat compared to a year earlier.

Undergraduate Studies

Professional chemists recommend several study areas that undergraduates might pursue. High on the list are biochemistry, polymer chemistry, writing, and computer science. **Page 30**

Demand

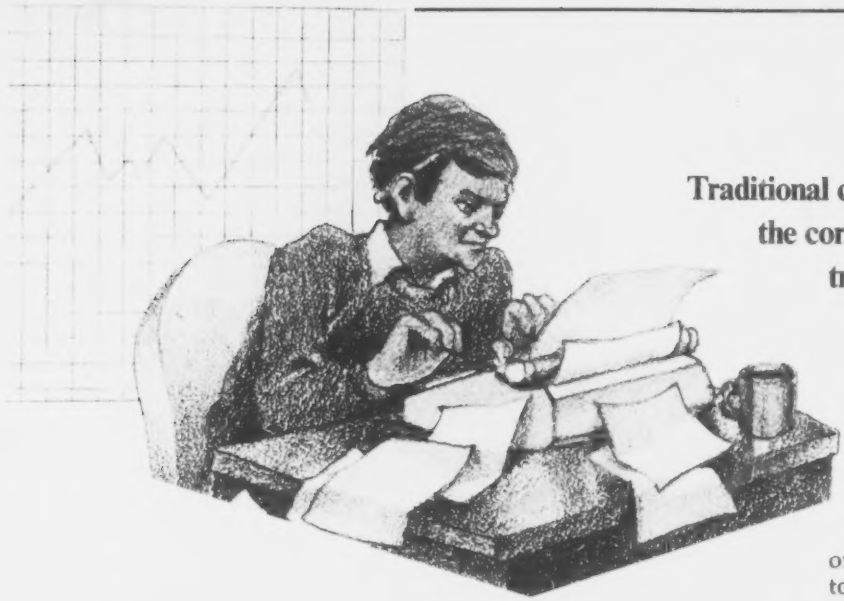
The pessimism that characterized the job market in 1983 has given way to a much brighter outlook this year as employers hire more chemists and chemical engineers. **Page 40**

Salaries

Salaries of experienced B.S., M.S., and Ph.D. chemists increased between March 1983 and March 1984, but not as much as in the previous 12 months. Salaries of new B.S. and Ph.D. chemists also rose. **Page 51**

Career Planning

The American Chemical Society and other organizations can supply a wide range of information to people looking for advice about careers in chemistry and chemical engineering. **Page 55**



Traditional chemistry may be the core to their undergraduate training, but B.S. chemists need to know much more

Undergraduate Studies

The key subdisciplines of chemistry are the essential foundation for any undergraduate aspiring to become a chemist. But chemists also must know more, much more, to succeed. Undergraduate training, therefore, must encompass a wide variety of both scientific and nonscientific subjects.

Among the sciences, for example, biochemistry and polymer chemistry have strong adherents; computer science and advanced mathematics are widely considered essential. Many industrial chemists, moreover, advocate training in industrial chemistry or chemical engineering—along with some work in business and management. Also, nearly everyone thinks that training in writing and public speaking is important for fledgling chemists.

Insights into the importance—or lack thereof—of various areas of undergraduate study show up in a survey carried out earlier this year by the American Chemical Society. The survey was conducted to determine how ACS members evaluate various areas of study, both in chemistry and other fields. Its results have been amplified with interviews C&EN has had recently with several experienced chemists.

As would be expected, the four core courses in chemistry—organic chemistry, analytical chemistry, physical chemistry, and inorganic chemistry—are cited most frequently as very important. These are courses that all students are required to take to get a B.S. degree in chemistry.

Of the four, organic chemistry gets the highest rating; 88% of the respondents consider it very important. On the other hand, physical chemistry is considered very important by only 74% and inorganic chemistry by only 73% of the respondents. In general, too, the core courses are rated somewhat higher by academic chemists than by those working in industry. Virtually no one, however, thinks any of them unimportant.

Despite widespread agreement that all undergraduates in chemistry should study these core subjects, some disagreement has developed regarding how much work should be required in each. The greatest controversy has centered on inorganic chemistry.

Twenty or 30 years ago, almost all chemistry majors took the equivalent of two semesters of inorganic chemistry. In fact, ACS-approved programs leading to a B.S. in chemistry required this.

In the late 1960s and early 1970s, many chemistry departments reduced the required amount of inorganic chemistry to one semester. One reason was that many students already had learned a good bit of inorganic chemistry in high school. The amount of study devoted to inorganic chemistry also was lessened to make room for increased work in physical chemistry and other chemical areas. In addition, many professors looked upon inorganic chemistry as a relatively inactive and unexciting field that needed less attention.

Reflecting this thinking, the ACS Committee on Professional Training in 1977 issued a new set of guidelines for ACS-approved curricula that, among other things, reduced the amount of required work in inorganic chemistry to one semester.

However, this change has met increasing opposition, especially from inorganic chemists, who think that inorganic chemistry is not being given enough emphasis. They point out that high schools now are teaching less inorganic chemistry than in the past. Furthermore, the subject is becoming a more active area of chemistry, particularly with the rapid development of semiconducting materials, organometallic compounds, and high-tech ceramics. As a result, the ACS committee issued new guidelines a year ago that require ACS-approved programs for B.S. chemists to contain the equivalent of approximately two full semesters of inorganic chemistry.

Some people argue, too, that students should take advanced elective courses in these core subjects of chemistry. For example, Jerry K. Larson, manager of employment at Pfizer's central research division in Groton, Conn., recommends that undergraduates who are specifically interested in a career in organic chemistry take one or two advanced courses in this area. "When we are

Four core courses in chemistry rate highly in ACS survey

	In current undergraduate curricula, this area is		
	Very important	Somewhat important	Not very important
CHEMISTRY			
Organic chemistry	88%	11%	1%
Analytical chemistry	82	16	2
Physical chemistry	74	22	4
Inorganic chemistry	73	24	3
Biochemistry	41	48	11
Polymer chemistry	31	52	17
Health and safety chemistry	31	51	18
Industrial chemistry	31	50	19
Chemical engineering	28	51	21
Surface chemistry and catalysis	22	57	21
Toxicology	17	52	31
Geochemistry	5	38	57

	In current undergraduate curricula, this area is		
	Very important	Somewhat important	Not very important
OTHER AREAS			
Writing and public speaking	73	25	2
Computer science	70	28	2
Calculus, linear algebra, and statistics	62	34	4
Information retrieval for chemists	55	39	6
Physics	44	45	11
Biology and other life sciences	33	54	13
Business and management	25	53	22
Foreign languages	19	49	32
Humanities	14	50	36
Social sciences	11	51	38

Source: American Chemical Society

Chemists have found writing useful in their own careers

	How useful was your undergraduate work in this area?			
	Very useful	Somewhat useful	Little use	Did no work
CHEMISTRY				
Organic chemistry	73%	22%	4%	1%
Analytical chemistry	69	23	6	2
Physical chemistry	54	31	12	3
Inorganic chemistry	54	33	10	3
Biochemistry	23	21	16	40
Polymer chemistry	13	13	12	62
Chemical engineering	14	11	7	68
Industrial chemistry	11	14	9	66
Health and safety chemistry	7	14	9	70
Surface chemistry and catalysis	9	15	14	62
Toxicology	5	9	9	77
Geochemistry	2	6	10	82

	How useful was your undergraduate work in this area?			
	Very useful	Somewhat useful	Little use	Did no work
OTHER AREAS				
Writing and public speaking	52	28	7	13
Calculus, linear algebra, and statistics	45	41	13	1
Information retrieval for chemists	32	29	11	28
Physics	30	41	25	4
Computer science	26	19	8	47
Biology and other life sciences	23	29	17	31
Foreign languages	16	37	36	11
Humanities	12	37	37	14
Business and management	11	18	13	58
Social sciences	8	33	37	22

Source: American Chemical Society

interviewing B.S. graduates to work in a synthetic organic chemistry lab," he says, "we generally are looking for people who have taken more than the required core course in organic. We prefer people who have done a senior research project in synthetic organic chemistry. People with such backgrounds become productive scientists in our laboratories much sooner."

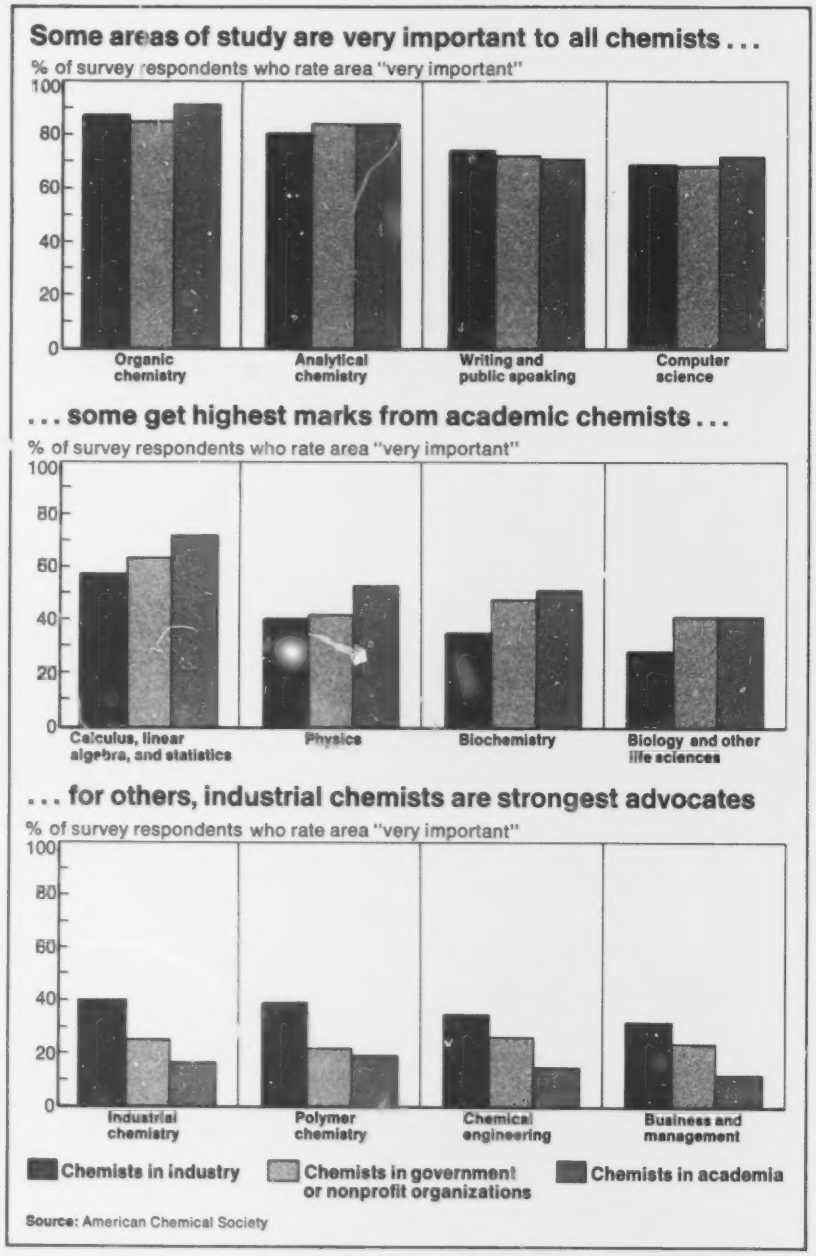
Larson, as well as other scientists, recommends that students do a senior research project if it is offered. The experience, they agree, greatly enhances B.S. chemists' laboratory training and improves the chances that they will get the job of their choice.

Biochemistry, although generally not required of undergraduates, also is highly rated; 41% of the ACS survey respondents think it is very important. Again, though, academic chemists rank it as a bit more important than chemists working in industry. And 38% of the respondents who had undergraduate training in biochemistry regard it as very useful and 35% as somewhat useful.

In fact, an increasing number of scientists—especially biochemists—urge that biochemistry be made at least a one-semester required course in the undergraduate curriculum. They believe that the amount of biochemistry that might be learned as part of a course in organic chemistry or biology is usually insufficient. C. David Gutsche, chemistry professor at Washington University in St. Louis, says, "In their heart of hearts, many biochemists, I believe, would like to see biochemistry as a core course in the undergraduate chemistry program."

Many faculty members point out that the undergraduate curriculum is only four years in length and that enlarging it to more than four years might impose a severe financial burden on many students who already are strapped with rising college costs. Moreover, the existing four-year curriculum is crammed with required elective courses, so if something is added, something must be eliminated. And few professors want anything dropped—particularly in their specialized fields.

Observers point out that biochemistry is becoming an increasingly important area because of the large-scale activity going on in such fields as molecular biology, biotechnology, pharmaceutical chemistry, and nutrition. A chemist who does not have a reasonably good understanding of these areas could be at a


Some areas of study are very important to all chemists . . .
% of survey respondents who rate area "very important"
100
80
60
40
20
0
Organic chemistry
Analytical chemistry
Writing and public speaking
Computer science
. . . some get highest marks from academic chemists . . .
% of survey respondents who rate area "very important"
Calculus, linear algebra, and statistics
Physics
Biochemistry
Biology and other life sciences
. . . for others, industrial chemists are strongest advocates
% of survey respondents who rate area "very important"
Industrial chemistry
Polymer chemistry
Chemical engineering
Business and management
Chemists in industry
Chemists in government or nonprofit organizations
Chemists in academia
Source: American Chemical Society

serious disadvantage professionally.

Karen W. Morse, head of the department of chemistry and biochemistry at Utah State University, says, "I am not one of those people who recommend that biochemistry be made a mandatory course for all B.S. chemists. However, I do believe that if students can fit a separate course in biochemistry into their schedules, it would be highly desirable for them to do so."

Larson of Pfizer notes that a one-semester course in biochemistry—however useful—is only an introduction to the subject and certainly does not make a person a biochemist. "When we are looking for B.S. people to work in biochemistry," he comments, "we prefer to hire those who have a B.S. in biochemistry, rather than a person with a B.S. in chemistry who has taken, let's say, only two courses in the subject."

One of the more frequent complaints made by industry recruiters is that most graduating chemists do not know enough about polymer chemistry. This field usually is covered in a course in organic chemistry and possibly in courses in general and physical chemistry. But many in industry believe that undergraduates also should take an elective course in polymer science.

This year's ACS survey found that 31% of the respondents view polymer chemistry as very important in the undergraduate curriculum. Of the 38% of the respondents who actually have had undergraduate work in polymers, 34% think that it was very useful to them and an equal number think it was somewhat useful. Industrial chemists, in particular, hold polymer training in high regard; 39% think it very important for undergraduates compared with only 19% among academic chemists.

Health and safety chemistry also is rated by 31% of the survey respondents as very important for undergraduate training. Perhaps reflecting the growing emphasis on health and safety matters in recent years, 48% of the respondents who received their B.S. degree during the 1980s rate this area highly, but less than 30% of those who graduated before 1979 do so.

Most chemists agree, to be sure, that every course in chemistry should stress the importance of avoiding health and safety hazards. They urge that alertness to hazards must be ingrained in chemistry students from the outset of their undergraduate education. But many also believe that most students get enough training in safety during their regular courses. Others, however, recommend that students take a one-semester course devoted solely to safety and health. Some schools offer such a course, but many do not.

Two other areas that many chemists consider important in the undergraduate curriculum are industrial chemistry and chemical engineering. This is especially the case with chemists employed by industrial firms. Industrial chemistry is viewed as very important by 40% of the industrial respondents but by only 16% of those at universities and colleges. Similarly, 35% of industrial chemists but just 15% of academic chemists rate chemical engineering very important.

Several years ago, some people were urging undergraduate chemistry majors to take three or more electives in chemical engineering. They reasoned that chemical engineers then had little difficulty in finding jobs with high salaries, but chemists were struggling to get jobs, even at appreciably lower salaries. The argument was that some training in chemical engineering made a chemist more marketable.

This argument lost much of its appeal as a glut of new chemical engineers developed last year, many of whom had more difficulty than chemists in finding jobs. This situation is likely to change in the next three or four years, however, as a decrease in the number of freshmen enrolled in chemical engineering results, in turn, in a declining number of graduates.

Some academic chemists, moreover, rebel at the idea of chemistry majors taking several electives in chemical engineering. Such training, they contend, deprives students of chemistry courses that should be part of their undergraduate studies. In addition, many professors are not comfortable with the notion of turning out graduates who are a hybrid of chemist and chemical engineer.

Undergraduates need to know more than just chemistry, to be sure. For example, advanced mathematics (calculus, linear algebra, and statistics) is rated as very important by 62% of the respondents to the ACS survey, although academic chemists consider it much more important than do chemists with industrial jobs. Some faculty members urge, for example, that chemistry majors take a separate course in statistics, noting that the attention given to the subject as part of conventional courses in analytical or physical chemistry often is inadequate.

Physics also is viewed as very important by 44% of the respondents, again with academic chemists giving it appreciably higher marks than it receives from industrial chemists. Actually, both calculus and physics are required parts of the undergraduate chemistry curriculum because both are prerequisites to the study of physical chemistry.

Rated even higher today, however, is training in computer science; 70% of the people covered by the ACS survey considered it very important, and it gets equally high marks from chemists who work in industry, the universities, government, and nonprofit organizations. Although some training in computers may be provided in such courses as analytical or organic chemistry, many experienced chemists think that undergraduates should take at least one or two electives in the use of computers.

One recent development has been a sharp rise in the number of freshmen who have become familiar with computers in high school. It is not unusual to find freshmen bringing personal computers to campus along with their hi-fi equipment and sports gear. Although this is not likely to eliminate the need for universities to teach computer science, it is likely to reduce the time needed to cover the basic information.

Edging out computer science in importance, however, is training in writing and public speaking. The ACS survey finds that 73% of chemists highly recommend these areas for undergraduates. Moreover, 60% of those who did undergraduate work in writing and public speaking consider them to have been very useful in their own careers; only 8% found them of little use.

Many employers say that the greatest deficiency of many new B.S. chemistry graduates is their failure to communicate effectively. Chemists need to write skillfully, they add, to convey ideas properly to coworkers, professional peers, supervisors, and even top management. Public speaking is similarly important.

Henry A. Bent, professor of chemistry at North Carolina State University, notes, "If you want to sell your ideas to other people, you need to express yourself skillfully." Adds Gutsche of Washington University, "I am appalled by the failure of many B.S. chemistry students to write literate English."

Many people argue that these are skills that actually should be acquired in high school. But what most students learn about writing and speaking in high school is inadequate.

One obvious place where college students might learn to write and speak competently is in the English courses that usually are required of freshmen. Many chemistry professors argue, however, that freshman English courses generally stress

Survey evaluates chemistry curriculum

Late last winter, as part of its annual survey of the salary and employment status of its members, the American Chemical Society also surveyed a large group of its members to determine what they think of the relative importance of various areas of study in the current curriculum leading to a bachelor's degree in chemistry. At the same time, respondents were asked to evaluate the usefulness of these study areas in their own chemical careers.

The original idea to conduct this survey was proposed last year by Gerhard G. Meisels, professor of chemistry and dean of the college of arts and sciences at the University of Nebraska, Lincoln, who at that time was chairman of the ACS Committee on Economic Status. Henry A. Bent, professor of chemistry at North Carolina State University, who is chairman of the ACS Committee on Professional Training, also supported the proposal.

Meisels and his committee believed that the education survey would help determine the preferred areas of study for B.S. chemists, so that chemistry graduates would be of greatest value to their employers. In turn, the committee thought, better education would lead to an improved economic status for chemists.

Bent believed the survey would be worthwhile because it would assist his committee in drawing up future ACS guidelines for the professional training of B.S. chemists. These guidelines, in turn, would be useful to departments of chemistry in formulating their educational programs and to chemistry professors in recommending courses of study to students.

Results of the survey are based on responses from about 10,600 ACS members, as compiled by the Statistical Services Office of the ACS Department of Professional Services.

creative writing, with a strong emphasis on fiction that encourages colorful, vague, and even florid writing. The emphasis often is on expressing feelings, rather than on stating facts, which is not the type of writing wanted in scientific reports meant to convey information and conclusions concisely and clearly.

Some chemistry professors declare that students can be taught to write proficiently in their chemistry courses. Examinations in all of these courses, they believe, should contain at least some short essay questions that are graded not merely for their factual content and scientific accuracy but for grammar and style. Chemistry professors and instructors should then point out to students where their writing is deficient.

Unfortunately, the majority of examinations in chemistry consist of multiple-choice questions or require the student merely to fill in blanks. Professors also are too busy with other responsibilities to edit the responses to essay questions and to improve students' writing quality.

In some science courses, however, students are called upon to write reports. Professors might well use these reports as a means of pointing out to students how their writing can be improved.

Some schools, recognizing that conventional English courses often do not place sufficient emphasis on the type of writing required of scientists, offer specialized courses in technical writing. Many people urge students to take such a course, or an elective in public speaking, to improve their effectiveness in communication.

Almost everyone agrees that B.S. chemistry students should be familiar with the methods available for obtaining scientific information from books, journals, and reports. This type of training is considered very important by 55% of the respondents to the ACS survey.

A widely held view, however, is that knowledge of chemical information retrieval, although quite valuable, usually can be learned satisfactorily as an adjunct to conventional chemistry courses. In the beginning stages of a senior research project, for example, students would be obliged to search the literature, which would give them useful experience in information retrieval.

Several years ago, many universities required B.S. chemistry students to study a foreign language, usually German because a substantial part of the chemical literature was published in German. But in recent years, this language requirement often has been dropped.

The ACS survey supports this decision. Only 18% of the respondents consider foreign languages a very important area of study and among recent graduates the percentage drops to 13%.

One reason is that many German scientists now publish their findings in English. Other German research papers are now available in English translations. The journal *Angewandte Chemie*, for example, has been available in both German and English for a number of years. And the next supplement of the Beilstein Handbook of Organic Chemistry (a series of books that will cover the literature from 1960 to 1979) will be published in English rather than in German.

Fifteen or 20 years ago, some chemists were also very interested in learning Russian because of the growing volume of chemical knowledge emanating from the Soviet Union. More recently, however, this interest has waned partly because many Russian scientific journals are now also published in English. In fact, many scientists believe that English is gradually becoming the universal language of science.

Some observers add that students would be much better advised to take one or more courses in computer science, rather than in a foreign language. They consider computer literacy a lot more important to chemists these days.

General agreement exists that universities are not trade schools and that university students should receive a reasonably well-rounded education. The function of four years of college leading to a B.S. degree in chemistry is not solely to teach a student about the sciences.

Gutsche says, "I definitely feel it would be unwise to curtail the nonscience undergraduate curriculum to make room for more science courses." Harry S. Hertz, director of the National Bureau of Standards' center for analytical chemistry, comments, "Courses in the humanities enrich a person's life. Besides, you definitely have to know more than chemistry when you interact with people in the great wide world."

Most professors emphasize that a chemistry education should give the student an opportunity to delve into many different fields of knowledge, such as humanities and fine arts, or social and behavioral sciences. These areas of study rank even lower than foreign languages in the ACS survey, though. A mere 14% of the respondents consider humanities and fine arts very important, and 10% rank social sciences as very important. On the other hand, 36% believe humanities and 38% believe social sciences are not very important. Among more recent graduates—those getting their B.S. since 1970—only about 10% view humanities as very important.

Some people, in industry particularly, recommend a course in business or economics, which, they believe, will give students working in industry a greater appreciation of the business world. For example, 25% of survey respondents think that training in business and management is very important. (Among academic chemists just 12% think such studies of much importance.) Dale B. Fox, technical employment manager at Monsanto, declares, "I believe a course in economics can be quite desirable for industrial chemists. Such a course can heighten a student's awareness that a chemical process can be a technical success but a business disaster because of economic conditions, such as the rising price of raw materials."

Another observer says, "You don't want to graduate B.S. chemists who can talk to other people only about chemistry, physics, and math. You want them to have a greater breadth of knowledge. You want them, if possible, to know about music, philosophy, anthropology, and psychology. You want to stimulate their interest in new areas of learning. In other words, you want them to develop an adequate appreciation of what constitutes world civilization—an appreciation that they will continue to expand in later years as they pursue further study and reading." □